FILE COPY ONLY PIBS 3616E

FILE COPY

FOLLOW-UP SOIL INVESTIGATION AT LIONS PARK, CAROLINE ST. PARK, AND ST. MARYS SCHOOL PORT HOPE (1997)

Ontario

Ministry
of the
Environment

ISBN 0-7778-7248-X

FOLLOW-UP SOIL INVESTIGATION AT LIONS PARK, CAROLINE ST. PARK, AND ST. MARYS SCHOOL PORT HOPE (1997)

February 1998

Cette publication technique
n'est disponible qu'en anglais.

Copyright: Queen's Printer for Ontario, 1998
This publication may be reproduced for non-commercial purposes
with appropriate attribution.

PIBS 3616e

Follow-up Soil Investigation at Lions Park, Caroline St. Park, and St. Marys School Port Hope (1997)

Ontario Ministry of the Environment
Standards Development Branch
Phytotoxicology Section

Investigator Author: Dave McLaughlin
Report Number: SDB-059-3511-97

Follow-up Soil Investigation at Lions Park, Caroline St. Park, and St. Marys School Port Hope (1997)

Executive Summary

Concentrations of antimony and lead exceeding health-based guidelines were discovered in Lions Park in a July 1996 Phytotoxicology investigation of soil quality at Port Hope schools. A follow-up investigation was conducted in April 1997, which included surface soil sampling and trenching in Lions Park, and surface soil sampling at St. Marys school and Caroline St. Park.

MOE health-based antimony clean-up guidelines were exceeded in surface soil at three sample sites, and lead in surface soil was exceeded at one sample site, all in the northeast corner of Lions Park in the immediate vicinity of the exclusion fence erected by the Town of Port Hope following the discovery of heavy metal contamination in 1996. The remaining play areas in the park, specifically the Family Resources Centre, the main playground equipment site, and the two baseball diamonds, are not contaminated. Debris believed to be Crane foundry waste was encountered in two of three trenches, buried at depths ranging from 0.5 to 1.5 metres. This at-depth waste was contaminated with copper, zinc, lead, barium, arsenic, and antimony at concentrations exceeding MOE effects-based guidelines.

Surface soil antimony concentrations at St. Marys school exceeded the health-based guideline at three of the five sample sites. Similarly, soil antimony exceeded the guideline at one of two sample sites at Caroline St. Park.

Because of the frequency of soil antimony guideline exceedences in Port Hope and the uncertainty regarding the validity of the clean-up guideline value (it is believed to be overly conservative), MOE health risk scientists reviewed the data from this study and the rationale for the antimony guideline. Their review concluded that there is no health risk to children from casual play in a park with soil antimony concentrations in the 10 to 1,000 μg/g range. Surface soil antimony concentrations did not exceed this range at any sites sampled in Lions Park, St. Marys School, or Caroline St. Park (the maximum surface soil concentration was 510 μg/g, which occurred at Lions Park).

Of the other soil contaminants encountered in the three study areas only lead poses a health concern. Surface soil lead concentrations averaged 770 μg/g in one area of Lions Park (east of the old tennis courts, outside of and immediately east of the exclusion fence erected by the town) and are high enough to warrant restricting access to children.

Follow-up Soil Investigation at Lions Park; Caroline St. Park, and St. Marys School Port Hope (1997)

Introduction

A July 1996 investigation of school play grounds in Port Hope by the Phytotoxicology Section of the Ontario Ministry of the Environment (MOE) detected significant surface soil heavy metal contamination in Lions Park, Port Hope[Ref 1]. This park was used as a play ground for St. Marys School during the 1995/96 school year. In addition to being used as the St. Marys playground, Lions Park is a popular community recreation area, and the site of a pre-school drop in centre. The extent of soil contamination in the park was unknown, as only one sample was collected from the northwest corner. Because surface soil in this area exceeded health-based guidelines for both lead and antimony, the Town of Port Hope, in council with the Medical Officer of Health, erected a fence around the sample area to restrict access to the contamination by children using the park.

The source of the contamination was believed to be Crane foundry waste. How the waste came to be deposited in the park is unknown, although it is suspected that the area currently occupied by Lions Park was a municipal dump at the turn of the century, which would have been an attractive location for the disposal of foundry waste.

Phytotoxicology Section scientists met with the Medical Officer of Health, officials from the Town of Port Hope, the staff from the Peterborough MOE District office, and the public in the early spring of 1997. A commitment was made to conduct a much more extensive soil investigation to characterize the extent and severity of soil contamination in Lions Park. In addition to more sampling in Lions Park, AECL's Low Level Radioactive Waste Management Office (LLRAWMO) suggested sampling surface soil at St. Marys School and Caroline St. Park, because recent remediation at these two sites revealed the presence of "clinkers", or slag-like material that is usually associated with solid historical industrial waste.

Sampling Strategy

This report summarizes the results of soil sampling from three separate areas; 1) Lions Park, 2) St. Marys School, and 3) Caroline St. Park. Appendix 1 provides a detailed description of each sample site from these three study areas. In addition to the sample site description, Appendix 1 identifies the data table in which the analytical results for each sample are summarized, the maximum gamma level for each site as measured by the LLRAWMO, and a precise site location using a satellite global positioning system. For example, the first sample site description in Appendix 1 is **West Diamond Bases,** which appears in bold font. This identifies a specific sample site (obviously collected from the base lines of the west ball diamond) and confirms the sample was obtained from Lions Park, and that the analytical results are summarized in Table 1. The same name, **West Diamond Bases**, is referenced in Table 1 and Figure 1. This nomenclature was used instead of sample site numbers to reduce confusion between sample sites (where the sample was actually collected) and study areas (the park that was sampled).

Surface soil samples (0-5 cm depth) were collected from the following areas in Lions Park on April 23, 1997:

- the infield of the west baseball diamond,
- the baselines of the west baseball diamond,
- the infield of the east baseball diamond,
- the baselines of the east baseball diamond,
- the centre field area between the two ball diamonds,
- the sodded play area of the Family Resources Centre (filled in pool),
- the sand from around the main playground equipment,
- inside the new fence erected by the Town (site of the original contamination),
- east of the new fence,
- the north play area (just west of the walkway bridge to St. Marys school),
- the northwest field,
- the mid-slope area of the sand hill,
- the southwest lawn (immediately west of the entrance off Gifford St.).

The sample areas in Lions Park are illustrated in Figure 1 and described in more detail in Appendix 1. The sample sites represent all the major play areas and routes commonly used to traverse the park. Because foundry waste was suspected of being buried, the Town of Port Hope arranged for a back hoe to dig three trenches to facilitate depth sampling. Trench 1 was located in the centre field area, between the two ball diamonds. Trench 2 was in the centre of the north play area, just north of the old tennis courts. Trench 3 was at the east edge of the north play area, south of the walkway bridge to St. Marys school. Trench 2 and 3 were in the general vicinity of the 1996 sample that identified heavy metal contamination in the northeast section of the park. The approximate locations of the three trenches are illustrated in Figure 1.

Surface soil samples were collected from the following areas from St. Marys School on April 23, 1997:

- exposed soil adjacent to both sides of the back stairway,
- exposed soil adjacent to the small concrete retainer at the base of the slope,
- exposed soil from under the small grove of maple and elm trees,
- gravelly sand adjacent to the play ground equipment,
- grassy area adjacent to the creek edge.

The sample areas from St. Marys School are illustrated in Figure 2 and described in more detail in Appendix 1. The sample sites represent the play areas in the school yard where soil is present (it is mostly paved) or, judging by the exposed soil, areas where foot traffic is greatest.

Surface soil samples were collected from the following areas from Caroline St. Park on April 23, 1997:

- east lawn area, north of the play ground equipment, east of the equipment shed,
- west lawn area, north of the parking lot

The sample sites from Caroline St. Park are illustrated in Figure 3 and described in more detail in Appendix 1. Activity at Caroline St. Park is centred around the enclosed hockey/lacrosse area and the playground equipment. The rest of the park is grassed field.

All samples were collected in duplicate using standard Phytotoxicology soil sampling protocols. The location of the sample sites was fixed using a Magellan satellite global positioning system. The samples were placed into new plastic bags and identified with unique field numbers. All samples were kept in view or locked while in storage until delivered to the Phytotoxicology sample processing laboratory. The samples were then dried for 36 hours, pounded to pass through a 2 mm sieve, and then the sieved fraction was ground to pass through a 355 micron sieve. The fine-sieved soil fraction was stored in a glass jar until shipped to the MOE Laboratory Services Branch for analysis of the following 22 inorganic elements: mercury, beryllium, magnesium, aluminum, calcium, vanadium, chromium, manganese, iron, cobalt, nickel, copper, zinc, molybdenum, cadmium, barium, lead, strontium, uranium, arsenic, selenium, and antimony.

Uranium and arsenic are known to be associated with emissions from Cameco and it's predecessor industries. Historical atmospheric emission rates of these two elements were much higher then present, and as a result of 40+ years of emissions a significant area of southern Port Hope, including the area around Lions Park and St. Marys School, has surface soil uranium and arsenic concentrations above background.

Lead and antimony, and possibly copper, zinc, molybdenum, and barium, are believed to be associated with emissions and waste from the Crane foundry. Crane was located at the Ganaraska River mouth and operated for many decades. Historical records are not clear, but this foundry was closed before the start of the Second World War, and possible quite a bit earlier. Soil contamination from this source tends to be quite severe but spotty, and concentrated in an area within about 1 km of the river mouth. This suggests that atmospheric emissions from Crane, although likely significant, were quite localized, and that disposal of foundry waste was the vehicle of more extensive contamination.

Results of Analysis:
Lions Park - Surface Soil

The results of the soil analysis of samples collected from Lions Park are summarized in Tables 1, 2, 3, and 4. Table 1 summarizes the results of surface soil (0 to 5 cm depth) samples from 13 sites.

Tables 2 to 4 summarize the results from the depth samples collected from the three trenches. Data exceeding the OTR guidelines are bold and underlined. Data exceeding the clean-up guidelines are shaded. OTR is an acronym for *Ontario Typical Range*. These are background-based guidelines that reflect the normal range of elements in soil collected from areas with no exposure to potential pollution sources. The MOE clean-up guidelines are effects-based and are set to protect the most sensitive environmental receptor (human, animal, or plant health). The derivation and use of these two guidelines are explained in Appendix 2 (OTR) and Appendix 3 (clean-up).

Calcium exceeded the OTR guideline (58,000 μg/g) at several sample sites in Lions Park. However, this simply reflects the large percentage of sand in many of the samples, as calcium is a major component of sand. Also, calcium is a significant constituent of limestone, and finely-crushed limestone was common along the baselines and the infields of the two baseball diamonds. There is no clean-up guideline for calcium because it is an important plant nutrient and naturally very abundant. Therefore, the elevated calcium concentrations have no environmental significance.

Zinc exceeded the OTR (140 μg/g), but not the clean-up guideline (600 μg/g), in soil collected from east of the exclusion fence and in the north play area. These two sites also had elevated soil lead levels, with the area east of the exclusion fence exceeding the lead health-based clean-up guideline (200 μg/g). The lead level at this site was 770 μg/g, which is comparable to the lead levels found in the same area of the park in the July 1996 sampling. Soil barium concentrations exceeding the OTR (180 μg/g) were also detected east of the exclusion fence.

Strontium concentrations exceeded the OTR guideline (78 μg/g) at eight of the 13 sample sites. This is unusual in that soil strontium background levels have a relatively narrow range and only rarely exceed the OTR. In the absence of a strontium source, previous Phytotoxicology studies have shown that whenever elevated strontium concentrations are detected it is usually in samples with a very high sand or limestone component. For example, the two highest strontium levels in Lions Park were from the baselines of the two ball diamonds, which were mostly finely-crushed limestone. The next two highest strontium levels were from almost pure sand samples (the sand hill and the main playground sand). The OTR data base is comprised of soil samples that were specifically chosen from medium and fine-textured soil types. Sandy and gravelly soils were avoided.

Strontium is not believed to be associated with emissions from Cameco, nor was it known to be part of the Crane foundry waste stream. The soil strontium:uranium and strontium:antimony ratios of samples from Lions Park further support the contention that strontium is not associated with either known source. There is an inverse relationship between soil strontium, uranium, and antimony concentrations; that is, the sites with the highest strontium levels (the ball diamond baselines, the sand hill, and the playground sand) had the lowest uranium and antimony levels.

There is no effects-based strontium soil clean-up guideline, as insufficient data were available to meet the MOE guideline development criteria. However, both AECB and MOE scientists concur that there are no health concerns with exposure to elemental strontium at near-background concentrations, such as those found in Lions Park.

In contrast, the radioisotope strontium^{90} is toxic. It is unlikely that this radioisotope, which was disbursed globally by atmospheric nuclear weapons testing, is a significant component of the strontium in the soil of Lions Park, as the maximum gamma radiation, as measured by the LLRAWMO at the time the samples were collected, did not exceed 7 μR/hr. Non-the-less, the AECB has agreed to initiate some preliminary strontium^{90} soil analysis in Port Hope to further investigate this issue.

Uranium concentrations in surface soil over a large area of Port Hope exceed the OTR (1.9 μg/g) as a result of more than 40 years of Cameco emissions. Previous Phytotoxicology sampling in the vicinity of Lions Park found that soil uranium concentrations in the 5 to 10 μg/g range were common. However, soil uranium concentrations from the 13 sites in Lions Park did not exceed 3.7 μg/g. A clean-up guideline for U has not been established, although a level of around 300 μg/g would not be unreasonable, based on effects on vegetation in studies using Ontario plants and soil conditions. A health effects level would be substantially higher.

Soil antimony concentrations exceeded the OTR (0.43 μg/g) at 11 of the 13 sample sites in Lions Park. However, only three sites, all in the northeastern corner of the park, exceeded the health-based clean-up guideline (13 μg/g). The highest soil antimony level, 510 μg/g (almost forty times the clean-up guideline), was detected just east of the exclusion fence. This site, which also had the highest mercury, copper, zinc, molybdenum, barium, lead, uranium, and arsenic levels was clearly the most contaminated surface soil site in the park. Close observation revealed that the surface was speckled with tiny white, red, and black fragments. The white pieces were ceramic chips, the red were brick fragments, and the black particles were weathered cinder. This material, which is believed to be associated with Crane foundry waste, likely worked it's way up through the sandy soil by frost action from large volumes of waste found to be buried at depth in the northeast section of the park.

Lions Park - Trench 1

Three trenches were dug by a back hoe provided by the Town of Port Hope to investigate the suspicion that the park site had been a municipal dump or had been used for foundry waste disposal. The first trench was 1.5 m deep, 5.5 m long, and oriented approximately north-south equidistant between the two baseball diamonds in the south end of the park (see Figure 1).

With the exception of a few centimetres of darker-coloured sandy loam soil associated with the turf layer at the surface, there were no recognizable soil horizons; the soil was a uniform fine sand the full depth of the trench. This indicates that the soil had not developed on site and the entire volume, at least to the trench depth of 1.5 m, had been brought in. Judging by the similarity in physical and chemical characteristics, and the proximity, the sand in the baseball diamond area of the park likely originated from the adjacent sand hill.

The only discrepancy in the trench profile was a very slight darkening that was evident between 80 cm and 1.2 m and intermittent along the 5.5 m trench face. In this band the soil remained the same fine sand, but there were a few small bone fragments, pieces of decayed wood, some clay nodules, and a small quantity of pyrite-like metallic flecks. This is suggestive of buried refuse, although very little material was actually observed at the trench site.

The results of the chemical analysis of the soil profile samples from Trench 1 are summarized in Table 2. Calcium, strontium, uranium, and antimony concentrations exceeded the OTR guideline in the surface soil samples (0 to 5 cm: these data are the same as in the *Diamond Centre Field* column of Table 1). Antimony remained above the OTR in the 10 cm and 30 cm sample depths. There was a clear depth gradient (decreasing concentrations with increasing depth) for uranium and arsenic, which are known to have contaminated surface soil in the park area from long-term atmospheric deposition from Cameco. This is expected, as the contaminants are relatively immobile in the soil environment, so they accumulate at the surface where they land and slowly work downwards with the vertical percolation of soil water. Arsenic has moved further down into the soil than uranium because arsenic is dissolved more readily in soil water.

Lead and antimony, the two contaminants associated with Crane waste, have a similar concentration gradient with depth. This suggests that lead and antimony were also deposited on the surface, and at least at this site, they are not associated with buried waste. The park was developed after the Crane foundry was closed, so the marginally elevated lead and antimony levels in the surface soil around Trench 1 must have originated from re-entrainment of near-by contaminated soil and not from atmospheric deposition.

The lack of physical evidence and the absence of significant metal contamination indicates that if either municipal or foundry waste are buried in the south end of Lions Park it is at a depth substantially greater than 1.5 m. Since this area is already depressed about 2 m relative to the local grade it is very unlikely any quantity of waste was ever buried in this part of the park.

Total gamma measurements taken by the LLRAWMO at the time of excavation did not exceed 7 μR/hr anywhere in the trench. The LLRAWMO has conducted extensive gamma measurements in Port Hope and concluded that normal background gamma is in the range of 4 to 7 μR/hr.

Lions Park - Trench 2

The second trench was dug in the centre of the north play area, north of the old tennis courts, in the northeast corner of the park, just to the west of the original July 1996 sample site where heavy metal contamination was discovered (see Figure 1). Trench number two was about 1.2 m deep and 3 m long. There were three obvious soil horizons in this trench: 1) a dark-grey loamy-sand surface soil associated with sod development that was about 10 cm deep, 2) a uniform light-coloured fine sandy loam extending to about 60 cm in depth, and 3) a layer of foundry waste from about 60 cm to at least 1.2 m, the depth of the trench. The foundry waste consisted of coarse aggregate material mixed with pieces of cinder, slag, chunks of coal, ceramic, disintegrated brick, charcoal, pieces of wood, and some metal. Although most of the material was very small (similar in size to finely-crushed limestone), some pieces, particularly the ceramics and bricks, were fist-sized. Brick fragments were often heat-glazed on one side, indicating they were likely fire brick. Based on the chemical characteristics, the low background radiation, and the presence of ceramic and brick fragments, the waste obviously originated from the Crane foundry.

The analytical results for Trench 2 are summarized in Table 3. The surface soil calcium, zinc, lead, strontium, and antimony concentrations exceeded the OTR guidelines (these are the same data in Table 1 identified as *North Play Area*). The antimony level at the surface was about 10 times the health-based clean-up guideline. The foundry waste at both 70 and 90 cm depths was clearly contaminated with metals, particularly copper, zinc, molybdenum, barium, lead, and antimony, all of which exceeded the OTR. The zinc, barium, lead, and antimony levels also exceeded the clean-up guidelines. The waste had the characteristic lead:antimony ratio of about 1:1, which is consistent with other lead and antimony contaminated sites in Port Hope that are suspected of originating from the Crane foundry. Considerable quantities of foundry waste has been buried at depth at this location. An attempt to determine the thickness of the waste layer, and therefore estimate it's volume, was not made because of the practical and safety limitations of the back hoe for deep excavation. In addition, unlike a borehole device, a back hoe excavates a considerable amount of material, and in this case the contaminated material buried at depth is dumped at the surface, which enhances the potential for the spread of heavy metal contamination in this area of the park. Therefore, trenching was minimized.

Total gamma measurements taken by the LLRAWMO at the time of excavation did not exceed 15 μR/hr anywhere in the trench.

Lions Park - Trench 3

The third trench was dug east of the exclusion fence, south of the walkway bridge, and north of the oak trees (see Figure 1). It was about 3 m long and 1.2 m deep. There were four distinct horizons: 1) a dark-grey loamy-sand surface soil associated with sod development that was about 10 cm deep, 2) a uniform light-coloured fine sandy loam extending to about 50 cm in depth, 3) a layer of foundry waste starting at about 50 cm and varying in thickness from as narrow as 10 cm to as thick as 60 cm, being thinner on the creek side of the trench, and 4) red-brown sand immediately above and below the foundry waste layer. The foundry waste in Trench 3 contained the same extraneous debris as the waste from Trench 2.

The analytical results for Trench 3 are summarized in Table 4. The non-waste soil at the 30 cm depth from Trench 3 had zinc and antimony levels above the OTR guidelines, although only antimony exceeded the clean-up guideline. The foundry waste was contaminated (exceeded the OTR) with mercury, copper, zinc, molybdenum, cadmium, barium, lead, strontium, uranium, arsenic, selenium, and antimony. Copper, zinc, lead, arsenic, and antimony exceeded the clean-up guidelines.

Two samples of the red-brown sand were collected; one from 50 cm, immediately above the foundry waste layer, and the second from 80 cm, which was about 20 cm below the foundry waste. Metal levels tended to be higher in the red-brown sand closest to the foundry waste.

Trench 3 was the closest of the trenches to vegetation (other than lawn grass). Tree roots were commonly observed in the sandy soil above and below the foundry waste layer, but completely absent in the waste layer. This likely reflects the phytotoxicity of the copper, zinc, and arsenic contamination in the waste material. The clean-up guideline for these three elements is based on plant injury, not human health.

Total gamma measurements taken by the LLRAWMO at the time of excavation did not exceed 11 μR/hr anywhere in the trench.

St. Marys School

The results of the soil samples collected from St. Marys school are summarized in Table 5. Most of the area behind the school is paved, and there are relatively few sample opportunities. The samples were collected where the ground was obviously trampled, indicating areas where the children played frequently. The approximate sample sites are illustrated in Figure 2.

The uranium and arsenic concentrations were lower than expected, based on known gradients of these elements in surface soil across Port Hope. Soil collected adjacent to the back stairs had marginally elevated concentrations of mercury, molybdenum, and cadmium (slightly above the OTR). There were no physical signs of contamination at this site - no unusual odour or colour, no brick, ceramic, or cinder pieces were evident; therefore there is no obvious explanation for these slightly higher than normal metal levels.

Strontium concentrations exceeded the OTR at four of the five sample sites. Like almost all samples from the near-by Lions Park, strontium appears to be associated with the high sand and/or limestone content of the St. Marys' soil samples. To illustrate this, the gravelly sand from the play set had the highest strontium levels on the school property, and the lowest concentrations of most of the other elements, particularly the metals associated with Cameco or Crane contamination.

All five of the sample sites had soil antimony concentrations that exceeded the OTR and three sites (back stairs, under the maple and elm grove, and adjacent to the creek edge) exceeded the health-based clean-up guideline. Very few tiny fragments of what appeared to be brick and possibly ceramics were observed on the surface of the soil at only two of the six sites: adjacent to the concrete retainer, and beneath the maple and elm grove. The source of the antimony contamination is not buried foundry waste because the sample sites are very unlikely to be depth-disturbed. For example, the samples collected from adjacent to the concrete retainer and from beneath the elm and maple trees, are from the foot of the steep embankment along the north side of the school property. It would not be possible to bury waste along the embankment talus without excavating into the slope. Similarly, material buried near the creek edge would be obvious (which it wasn't) because of stream bank erosion. Also, the coarse gravelly sand from the play set is extremely well drained, making it unlikely that the marginally elevated antimony levels at this site originated from buried waste that had migrated to the surface. Therefore, the antimony may have fallen into the school yard from contaminated soil higher up the embankment, was re-entrained via foot traffic from the highly contaminated surface soil across the bridge in Lions Park, or was residual contamination remaining after the remediation/containment of other areas of the school yard by the LLRAWMO.

Total gamma measurements taken by the LLRAWMO at the time of sampling did not exceed 8 μR/hr at any of the school sample sites.

Caroline St. Park

In 1994 the Port Hope rotary club redeveloped Caroline St Park. The LLRAWMO assisted in removing and consolidating approximately 671 m^3 of radium-contaminated soil from the park, while another 320 m^3 of slightly contaminated soil was consolidated beneath the parking lot on site. During the renovation the LLRAWMO noted that the northwest end of the park had many clinkers, or slag-like material, which was believed to be associated with Crane foundry waste.

The analytical results of the soil samples collected from Caroline St. Park on April 23 1997 are summarized in Table 6. The two sample sites are illustrated in Figure 3. The soil on the east side of the park adjacent to the north side of the play equipment exceeded the zinc and antimony OTR guidelines. The soil from the grassed playing field on the west side of the park north of the parking lot exceeded the zinc, barium, and lead OTR guidelines, and the antimony health-based clean-up guideline. Since the park is outside of the area of substantial historic atmospheric fallout, this residual contamination must be associated with the waste identified and remediated/consolidated by the LLRAWMO. An area that received Cameco waste was likely just as attractive a site for the disposal of Crane waste, although the Crane waste would have been dumped first.

Total gamma measurements taken by the LLRAWMO at the time of sampling did not exceed 7 μR/hr at either of the park sample sites.

Comments on the Origin and Health Implications of Soil Antimony Concentrations in Port Hope

Antimony is a heavy metal that is ubiquitously present in Ontario soil at very low concentrations. The background range is well defined and very narrow, so levels above the OTR are virtually always associated with an industrial antimony source.

The extent of antimony contamination in surface soil in Port Hope is not well defined. In Port Hope antimony is most often a co-contaminate of lead, commonly occurring in a lead:antimony ratio of about 1:1. This chemical ratio is consistent in areas in town where significant antimony and lead contamination has been found. Believed to be associated with Crane foundry waste, lead and antimony concentrations can exceed 1,000 μg/g in surface soil. Contamination at depth has been documented in excess of 4,000 μg/g. Pockets of Crane waste are usually confined to a specific location, so that the antimony levels can be very high but the spacial distribution of the contaminant is very limited. In this fashion "hot spots" of antimony and lead contamination are scattered across Port Hope. Most notably, high soil antimony levels have been found in the northeast section of Lions Park, the west bank of the Ganaraska River under the railway trestles, and the marina park area on the east side of the river. Soil lead and antimony contamination could turn up almost anywhere in Port Hope, as foundry waste disposal was not regulated.

In addition, a weak antimony contamination gradient is evident in surface soil over a wider area of Port Hope, with concentrations decreasing with increasing distance from the river mouth. The antimony contamination gradient is not as clear or as well defined as the soil uranium and arsenic gradients. This suggests that in addition to the disposal of solid Crane foundry waste, antimony was spread over a wider area by atmospheric emissions. It stands to reason that Crane would have had atmospheric emissions and that these would have contaminated the soil in the vicinity of the foundry. With the passage of time (the Crane foundry has been closed for at least 50 years) the surface soil contamination gradient would become less evident, as the material settles deeper into the soil, is dispersed over a wider area by re-entrainment, and areas are redeveloped. This, combined with the history of haphazard waste disposal, has resulted in the present situation where surface soil antimony concentrations in excess of the OTR guideline occur in many areas of Port Hope.

Because of the frequency of soil antimony OTR and clean-up guideline exceedences in Port Hope, and the uncertainty regarding the validity of the clean-up guideline value (it is believed to be overly conservative), MOE health risk scientists reviewed the data from this study and the rationale for the antimony guideline, specifically as it relates to casual exposure, such as a child playing in a park with elevated antimony levels in the surface soil. There is no direct epidemiological evidence of antimony causing adverse human health effects, except with very high occupational exposures. Information on the toxicity of antimony in animals is limited to a single study that was seriously flawed and from which few confident conclusions can be drawn. Nevertheless, this study served as the basis for the development of the US EPA antimony reference dose (RfD - a reference dose refers to the amount of a contaminant that can be taken into the body *from all sources on a daily basis over* *a lifetime that should not result in a measurable health effect*). The US EPA attached a very large safety factor to the R*f*D (1,000) to reflect this uncertainty. The uncertainty in the antimony R*f*D was not considered in the development of the MOE soil guideline, which is in keeping with the generic nature of the guideline development process. Also, the MOE soil guideline process[Ref 2] employed other conservative assumptions, such as 100% bioavailability and lifetime exposures, which in some cases tends to drive the guidelines lower. In addition, the MOE 1991 Port Hope human health risk assessment[Ref 3] concluded that soil antimony concentrations up to 1,200 μg/g were not a health risk to the community. In review of these considerations, with specific reference to the results of this April 1997 Phytotoxicology investigation of school and parkland soil contamination, MOE health risk scientists concluded that there is no health risk to children casually playing in a park with soil antimony levels in the 10 to 1,000 μg/g range.

Conclusions

The April 1997 Phytotoxicology investigation confirmed that the surface soil metal contamination detected in Lions Park in July 1996 is confined to a small area in the northeast corner of the park in the general vicinity of the exclusion fence erected by the town. The contamination originated from buried Crane foundry waste. This waste is finely-aggregate in nature and tends to move upwards with frost action, in the same manner that stones erupt from farm fields. Based on the limited trenching exercise, the south end of Lions Park had likely received some municipal waste but little, if any, foundry waste, whereas the northeast section of the park had received some municipal waste and an abundance of foundry waste. Caution should be exercised in future construction or renovation projects at Lions Park that involve soil excavation, to insure that contaminated waste buried at depth isn't brought to the surface.

Although studies to date have centred on Crane being a source of heavy metal contamination associated with buried waste, during it's operation the foundry was likely a significant source of atmospheric emissions, particularly antimony and lead, and possibly barium, zinc, copper, and molybdenum. These atmospheric emissions almost certainly resulted in substantial heavy metal soil contamination in the vicinity of the foundry. With the passage of time this soil contamination has been reduced in severity near the foundry site but dispersed over a larger area through re-entrainment. The process of re-entrainment combined with the unregulated and likely widespread practice of foundry waste burial has resulted in surface soil metal concentrations in Port hope that are frequently above normal background ranges, and scattered, very localized, hot spots of significantly elevated metal levels, particularly lead and antimony.

The soil antimony contamination detected at St. Marys School is not likely associated with buried waste because the concentrations at the surface were much lower than other areas where waste has been confirmed, and very little physical evidence (cinder, brick, and ceramic) was observed. This marginal contamination has probably been transported on site by the very high volume of foot traffic between the school yard and the adjacent northeast corner of Lions Park, where surface soil antimony concentrations are much higher. Also, it may have originated from the waste that was remediated/contained by the LLRAWMO elsewhere on the school grounds.

The soil antimony contamination at Caroline St. Park is probably related to re-entrainment of buried waste, as the LLRAWMO observed clinkers and other debris on site during the removal and containment of low level radioactive debris. A site that was attractive for historical waste disposal by Cameco's predecessor companies would have been equally attractive to Crane, although the Crane dumping would have occurred first. Soil remediation carried out by the LLRAWMO to address radioactive waste at Caroline St. Park has substantially reduced, but not eliminated, the heavy metal contamination associated with the Crane foundry waste.

Because of the frequency of soil antimony guideline exceedences in Port Hope and the uncertainty regarding the validity of the clean-up guideline value (it is believed to be overly conservative), MOE health risk scientists reviewed the data from this study and the rationale for the antimony guideline. Their review concluded that there is no health risk to children from casual play in a park with soil antimony concentrations in the 10 to 1,000 μg/g range. Surface soil antimony concentrations did not exceed this range at any sites sampled in Lions Park, St. Marys School, or Caroline St. Park.

Of the other soil contaminants encountered in the three study areas only lead poses a health concern. Surface soil lead concentrations averaged 770 μg/g in one area of Lions Park (east of the old tennis courts, outside of and immediately east of the exclusion fence erected by the town) and are high enough to warrant restricting access to children.

References

Reference 1 *Phytotoxicology Soil Investigation at Port Hope Schools: July 1996.* Ontario Ministry of Environment and Energy. April 1997.

Reference 2 *Rationale for the Development and Application of Generic Soil, Groundwater, and Sediment Criteria for Use at Contaminated Sites in Ontario.* Ontario Ministry of Environment and Energy. May 1996.

Reference 3 *Assessment of Human Health Risk of Reported Soil Levels of Metals and Radionuclides in Port Hope.* Ontario Ministry of the Environment. June 1991.

Table 1: Results of Surface Soil Sampling - Lions Park, Port Hope, April 23, 1997

Element	West Diamond Bases	West Diamond Infield	Diamond Centre Field	East Diamond Bases	East Diamond Infield	Family Resources Centre	Main Playground (sand)	Inside Exclusion Fence	East of Exclusion Fence	North Play Area	NorthWest Field	Sand Hill	South West Lawn	Guidelines	
														OTR	Clean-Up
Mercury	0.01W	0.03T	0.05	0.01W	0.03T	0.04T	0.01W	0.04T	0.08	0.05T	0.02T	0.01T	0.03T	0.18	10
Beryllium	0.5W	0.5W	0.5W	0.5W	0.5W	0.5W	0.5W	0.5W	0.5W	0.5W	0.5W	0.5W	0.5W	0.97	1.2
Magnesium	5,800	3,400	5,000	6,100	4,400	4,800	3,500	3,350	2,600	4,900	3,800	4,100	3,500	16,000	NG
Aluminum	4,800	5,400	5,600	5,200	6,500	13,000	2,500	10,100	9,250	4,850	5,650	2,150	6,100	27,000	NG
Calcium	***135,000***	46,000	***61,000***	***120,000***	52,500	36,000	***100,000***	27,000	20,500	***79,000***	***62,000***	11,000	48,000	58,000	NG
Vanadium	23	20	24	23	22	34	20	29	27	19	19	20	23	71	200
Chromium	10	10	16	11	11	22	7	17	18	10	11	7	11	62	750
Manganese	275	210	275	295	295	415	175	270	220	220	280	175	260	1,300	NG
Iron	12,500	9,600	12,000	12,000	11,000	17,000	9,000	15,000	16,000	10,150	9,200	9,900	12,000	33,000	NG
Cobalt	3.3	2.9	4.4	3.5	3.3	6.1	1.6T	5.5	4.6	2.8	3.3	2.0T	3.3	17	40
Nickel	5.5	5.0	8.0	5.4	6.5	12	2.7T	10.1	11	5.8	5.8	2.8	5.9	32	150
Copper	6.5	6.5	9.5	7	8	13	2.5T	12	25	21	5.5	2.0T	6.0	65	225
Zinc	29	39	53	28	40	49	13T	100	***525***	***160***	33	8.5T	49	140	600
Molybdenum	0.5W	0.5W	0.5W	0.5W	0.5W	0.5W	0.5W	0.5W	0.8T	0.5W	0.5W	0.5W	0.6T	0.85	40
Cadmium	0.2W	0.2W	0.2W	0.2W	0.2W	0.2W	0.2W	0.3W	0.3T	0.2W	0.3T	0.2W	0.3T	0.84	12
Barium	56	32	42	52	38	95	11	66	430	101	33	11	28	180	750
Lead	4.5T	19	24	5T	16	22	2W	98	***770***	***170***	17	2	19	98	200
Strontium	***175***	71	***92***	***165***	***80***	60	***140***	45	38	***115***	***89***	***140***	70	78	NG
Uranium	0.6T	***2.9***	***2.5***	0.6T	***2.6***	1.0T	0.3W	***3.1***	***3.7***	1.2	1.0	0.4T	***3.6***	1.9	NG
Arsenic	2.1	3.5	5.4	2.3	4.5	5.9	1.9	14	7.8	4.4	2.0	1.2	3.0	17	20
Selenium	0.2W	0.2W	0.2W	0.2W	0.2W	0.3T	0.2W	0.2W	0.2W	0.2W	0.2W	0.2W	0.2W	1.3	10
Antimony	***0.5T***	***1.2***	***1.7***	***0.8T***	***2.1***	***0.7T***	0.3W	***21***	***510***	***139***	***3.4***	0.3T	***1.5***	0.43	13

Data are μg/g, mean of duplicate samples
OTR - Ontario Typical Range are background based guidelines, see Appendix 2.
Clean-up guidelines are effects based, see Appendix 3.
Bold and underlined data exceed OTR guideline, shaded data exceed clean-up guidelines.
W - analytical detection limit, zero response. T - trace concentration, interpret with caution. NG - no guideline.
See Figure 1 for location of sample sites

Table 2: Results of Soil Sampling from Trench 1 (Baseball Diamond Area), Lions Park, April 23, 1997

Element	0-5 cm Sandy loam	10 cm Sand	30 cm Sand	60 cm Sand	100 cm Sand	Guidelines	
						OTR	Clean-up
Mercury	0.05	0.04T	0.06	0.04T	0.04T	0.18	10
Beryllium	0.5W	0.5W	0.5W	0.5W	0.5W	0.97	1.2
Magnesium	5,000	2,450	2,450	2,200	2,100	16,000	NG
Aluminum	5,600	5,950	5,500	4,900	4,800	27,000	NG
Calcium	***61,000***	32,000	34,000	33,000	33,500	58,000	NG
Vanadium	24	22	21	18	18	71	200
Chromium	16	10	8	8	7	62	750
Manganese	275	210	200	180	180	1,300	NG
Iron	12,000	11,000	10,100	8,800	8,800	33,000	NG
Cobalt	4.4	3.2	2.7	2.6	2.3T	17	40
Nickel	8.0	4.7	4.5	3.8	4.1	32	150
Copper	9.5	4.5	4.0	3.5T	3.0T	65	225
Zinc	53	24T	23	18T	15T	140	600
Molybdenum	0.5W	0.5W	0.5W	0.5W	0.5W	0.85	40
Cadmium	0.2W	0.2W	0.2W	0.2W	0.2W	0.84	12
Barium	42	26	23	21	19	180	750
Lead	24	11	10	12	5T	98	200
Strontium	***92***	51	53	51	53	78	NG
Uranium	***2.5***	0.8T	0.6T	0.4T	0.4T	1.9	NG
Arsenic	5.4	2.9	2.8	2.3	1.9	17	20
Selenium	0.2W	0.2W	0.2W	0.2	0.2W	1.3	10
Antimony	***1.7***	***0.6T***	***0.7***	0.4T	0.2W	0.43	13

Data are μg/g, mean of duplicate samples.
OTR - Ontario Typical Range are background based guidelines, see Appendix 2.
Clean-up guidelines are effects based, see Appendix 3.
Bold and underlined data exceed OTR guideline, shaded data exceed clean-up guideline.
W - analytical detection limit, zero response, T - trace concentration, interpret with caution.
NG - no guideline.
See Figure 1 for trench location.

Table 3: Results of Soil Sampling from Trench 2 (North Play Field), Lions Park, April 23, 1997

Element	0-5 cm Sandy Loam	30 cm Sandy Loam	70 cm Foundry Waste	90 cm Foundry Waste	Guidelines	
					OTR	Clean-up
Mercury	0.05T	0.02T	0.05	0.05	0.18	10
Beryllium	0.5W	0.5W	0.5W	0.5W	0.97	1.2
Magnesium	4,900	6,500	825	2,250	16,000	NG
Aluminum	4,850	3,900	11,000	9,600	27,000	NG
Calcium	***79,000***	93,000	6,800	17,500	58,000	NG
Vanadium	19	19	26	31	71	200
Chromium	10	8	26	29	62	750
Manganese	220	220	275	340	1,300	NG
Iron	10,150	8,700	27,000	29,000	33,000	NG
Cobalt	2.8	2.4	3.7	5.3	17	40
Nickel	5.8	3.6	19	26	32	150
Copper	21	4T	57	***86***	65	225
Zinc	***160***	23T	**1,780**	**1,340**	140	600
Molybdenum	0.5W	0.5W	***2.2***	***2.2***	0.85	40
Cadmium	0.2W	0.2W	0.6T	0.3T	0.84	12
Barium	101	31	**1,810**	**1,180**	180	750
Lead	***170***	8	**1,430**	**1,280**	98	200
Strontium	***115***	***130***	43	48	78	NG
Uranium	1.2	0.4T	0.6T	0.8T	1.9	NG
Arsenic	4.4	1.7	10.6	7.9	17	20
Selenium	0.2W	0.2W	0.3T	0.2W	1.3	10
Antimony	**139**	***6.7***	**1,600**	**1,110**	0.43	13

Data are μg/g, mean of duplicate samples.
OTR - Ontario Typical Range are background based guidelines, see Appendix 2.
Clean-up guidelines are effects based, see Appendix 3.
Bold and underlined data exceed OTR guidelines, shaded data exceed clean-up guidelines.
W - analytical detection limit, zero response. T - trace concentration, interpret with caution. NG - no guideline.
See Figure 1 for trench location.

Table 4: Results of Soil Sampling from Trench 3 (South of Bridge), Lions Park, April 23, 1997

Element	30 cm Sandy Loam	50 cm Foundry Waste	60 cm Red-brown Sand	80 cm Red-brown Sand	Guidelines	
					OTR	Clean-up
Mercury	0.13	***3.0***	0.17	0.04T	0.18	10
Beryllium	0.5W	0.8	0.5W	***1.0***	0.97	1.2
Magnesium	2,300	2,200	590	7,000	16,000	NG
Aluminum	9,500	9,800	11,000	23,000	27,000	NG
Calcium	14,000	40,000	3,300	9,400	58,000	NG
Vanadium	30	36	23	51	71	200
Chromium	17	29	19	42	62	750
Manganese	220	250	130	540	1,300	NG
Iron	16,000	19,000	15,000	27,000	33,000	NG
Cobalt	4.4	9.3	1.9	10	17	40
Nickel	10	28	18	22	32	150
Copper	51	**1,300**	63	26	65	225
Zinc	***180***	**2,400**	***250***	54	140	600
Molybdenum	0.5W	***2.8***	***2.6***	0.5W	0.85	40
Cadmium	0.3T	***5***	0.5	0.2W	0.84	12
Barium	100	***460***	150	150	180	750
Lead	84	**720**	***100***	13	98	200
Strontium	30	***140***	18	35	78	NG
Uranium	1.0	***2.0***	1.3	0.5T	1.9	NG
Arsenic	9.5	**49**	14	2.8	17	20
Selenium	0.2W	***8.3***	0.3	0.2	1.3	10
Antimony	**57**	**30**	**63**	***1.2***	0.43	13

Data are μg/g, single samples.
OTR - Ontario Typical Range are background based guidelines, see Appendix 2.
Clean-up guidelines are effects based, see Appendix 3.
Bold and underlined data exceed OTR guidelines, shaded data exceed clean-up guidelines.
W - analytical detection limit, zero response. T- trace concentration, interpret with caution. NG - no guideline.
See Figure 1 for trench location.

Table 5: Results of Surface Soil (0-5 cm) Sampling from St. Marys School, April 23, 1997

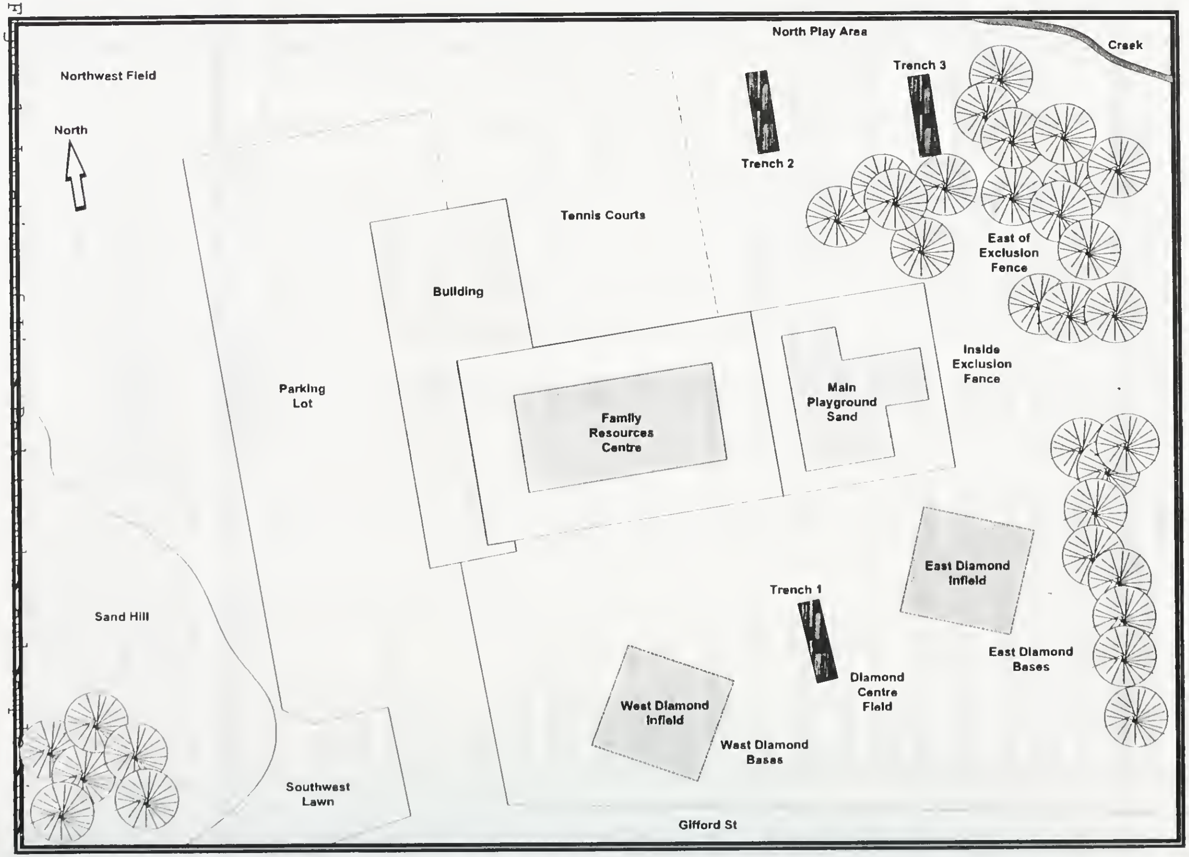
Element	Adjacent to Back Stairway	Adjacent to Concrete Retainer	Maple and Elm Grove	Gravelly-sand from Play Set	Adjacent to Creek Edge	Guidelines	
						OTR	Clean-up
Mercury	***0.36***	0.05T	0.06	0.01W	0.02T	0.18	10
Beryllium	0.5W	0.5W	0.5W	0.5W	0.5W	0.97	1.2
Magnesium	4,700	3,400	1,600	4,200	4,400	16,000	NG
Aluminum	5,400	4,200	4,600	3,200	8,100	27,000	NG
Calcium	52,000	***75,000***	11,000	13,000	17,000	58,000	NG
Vanadium	23	20	21	21	22	71	200
Chromium	20	11	11	8.0	16	62	750
Manganese	250	215	240	250	200	1,300	NG
Iron	12,500	10,300	10,300	12,000	10,000	33,000	NG
Cobalt	3.7	2.9	3.0	2.6	4.3	17	40
Nickel	9.5	4.3	4.5	3.4	11	32	150
Copper	13	8.0	5.0	4.0T	12	65	225
Zinc	102	58	52	27	61	140	600
Molybdenum	***1.4T***	0.5W	0.5W	0.5W	0.5W	0.85	40
Cadmium	***2.0***	0.2W	0.3T	0.2W	0.2W	0.84	12
Barium	55	32	37	19	70	180	750
Lead	70	53	48	16	32	98	200
Strontium	***94***	***105***	21	***170***	***102***	78	NG
Uranium	1.9	1.3	***2.1***	0.8T	1.7	1.9	NG
Arsenic	3.7	2.3	5.5	1.7	2.4	17	20
Selenium	0.2W	0.2W	0.5T	0.2W	0.3T	1.3	10
Antimony	**30**	***5.2***	**20**	***6.5***	**17**	0.43	13

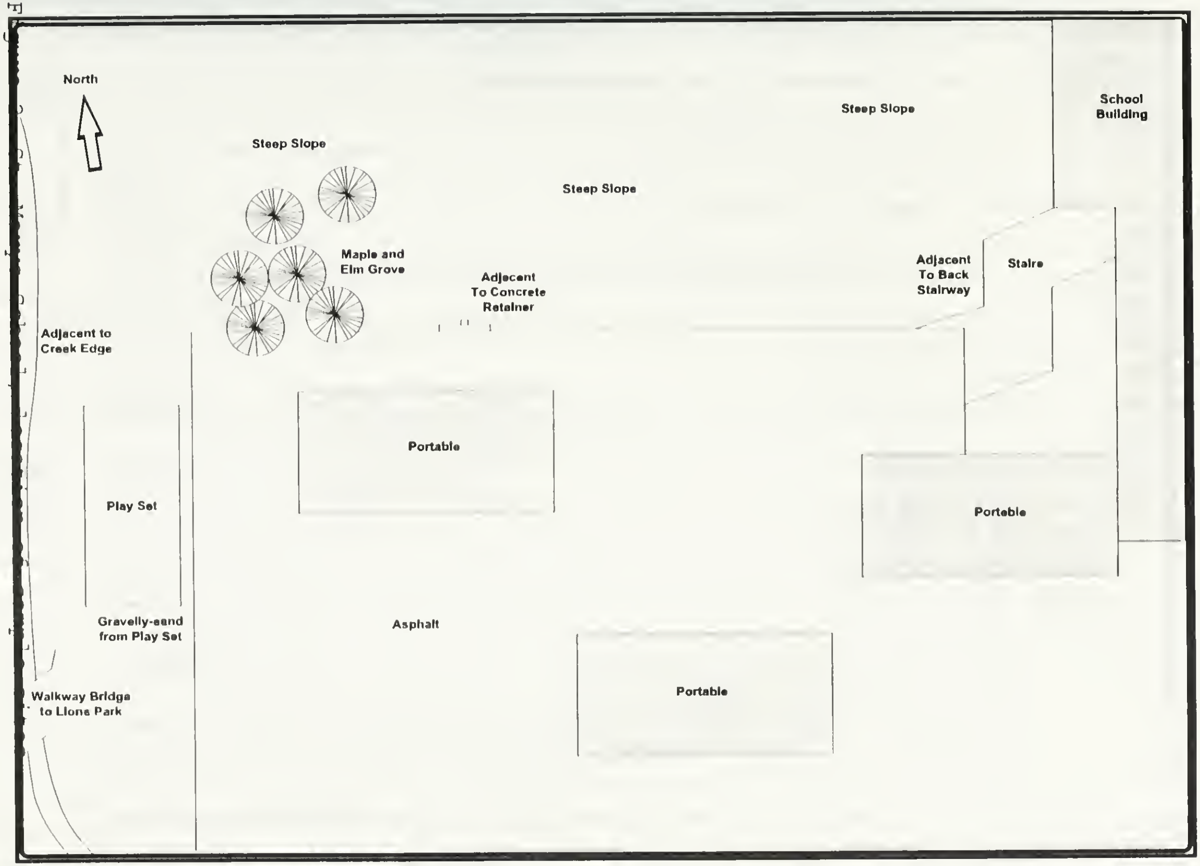
Data are μg/g, mean of duplicate samples.
OTR - Ontario Typical Range are background based guidelines, see Appendix 2.
Clean-up guidelines are effects based, see Appendix 3.
Bold and underlined data exceed OTR guideline, shaded data exceed clean-up guidelines.
W - analytical detection limit, zero response, T - trace concentration, interpret with caution.
NG - no guideline.
See Figure 2 for location of sample sites.

Table 6: Results of Surface Soil (0-5 cm) Sampling from Caroline St. Park, April 23, 1997

Element	East Side North of Play Equipment	West Side North of Parking Lot	Guidelines	
			OTR	Clean-up
Mercury	0.06	0.04T	0.18	10
Beryllium	0.5W	0.5W	0.97	1.2
Magnesium	3,700	3,500	16,000	NG
Aluminum	11,000	10,000	27,000	NG
Calcium	19,000	20,000	58,000	NG
Vanadium	32	32	71	200
Chromium	20	22	62	750
Manganese	255	370	1,300	NG
Iron	16,000	20,000	33,000	NG
Cobalt	5.9	6.0	17	40
Nickel	10	14	32	150
Copper	10	26	65	225
Zinc	***220***	***330***	140	600
Molybdenum	0.5W	0.5W	0.85	40
Cadmium	0.4T	0.3T	0.84	12
Barium	63	***245***	180	750
Lead	29	***103***	98	200
Strontium	35	36	78	NG
Uranium	1.7	1.2	1.9	NG
Arsenic	4.4	6.4	17	20
Selenium	0.2W	0.2W	1.3	10
Antimony	***3.3***	**155**	0.43	13

Data are μg/g, mean of duplicate samples.
OTR - Ontario Typical Range are background based guidelines, see Appendix 2.
Clean-up guidelines are effects based, see Appendix 3.
Bold and underlined data exceed OTR guidelines, shaded data exceed clean-up guidelines.
W - analytical detection limit, zero response, T - trace concentration, interpret with caution. NG - no guideline.
See Figure 3 for location of sample sites.


North Play Area
Creek
Northwest Field
North
Trench 3
Trench 2
Tennis Courts
East of Exclusion Fence
Building
Inside Exclusion Fence
Parking Lot
Main Playground Sand
Family Resources Centre
East Diamond Infield
Trench 1
Sand Hill
East Diamond Bases
Diamond Centre Field
West Diamond Infield
West Diamond Bases
Southwest Lawn
Gifford St


North
Steep Slope
Steep Slope
Steep Slope
School
Building
Maple and
Elm Grove
Adjacent
To Concrete
Retainer
Adjacent
To Back
Stairway
Stairs
Adjacent to
Creek Edge
Portable
Portable
Portable
Play Set
Gravelly-sand
from Play Set
Asphalt
Walkway Bridge
to Lions Park

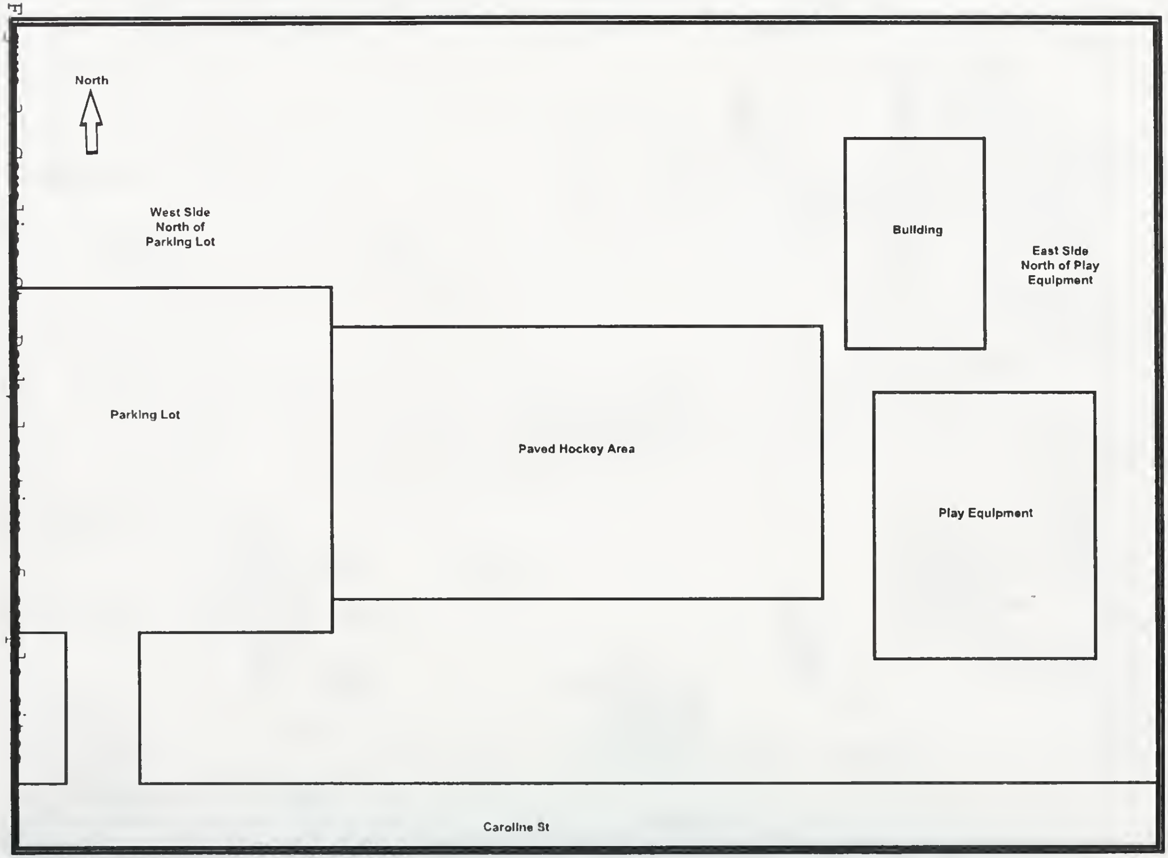


Figure 2. Caroline St. Park, location of sample sites

Appendix 1: Description of Sample Sites, Data Table Reference, Maximum Gamma Levels, and Site UTM Co-ordinates.

Location	Table Reference	Detailed Description	Maximum Gamma μR/hr	GPS UTM	
				Easting	Northing
Lions Park	Table 1	**West Diamond Bases**: gravelly-sand (0-5 cm) collected from the baseline of the west baseball diamond.	5	716650	4869670
Lions Park	Table 1	**West Diamond Infield**: sandy loam (0-5 cm) collected from the infield of the west baseball diamond.	5	716660	4869670
Lions Park	Table 1	**Diamond Centre Field**: sandy loam (0-5 cm) collected from the outfield area midway between the two baseball diamonds.	6	716670	4869746
Lions Park	Table 1	**East Diamond Bases**: gravelly-sand (0-5 cm) collected from the baseline of the east baseball diamond.	5	716680	4869700
Lions Park	Table 1	**East Diamond Infield**: sandy loam (0-5 cm) collected from the infield of the east baseball diamond.	5	716670	4869695
Lions Park	Table 1	**Family Resources Centre**: clay loam (0-5 cm) collected from the grassed play area inside the fence of the Port Hope Resources Centre.	5	716630	4869720
Lions Park	Table 1	**Main Playground (sand)**: sand collected from around the play ground equipment immediately east of the Family Resources Centre.	5	716660	4869720
Lions Park	Table 1	**Inside Exclusion Fence**: sandy loam (0-5 cm) collected from inside the fence erected by the Town of Port Hope around the original contamination site, east of the playground equipment beside the Family Resources Centre. Few very small black cinder-like and white ceramic-like pieces observed on the surface.	6	716670	4869740
Lions Park	Table 1	**East of Exclusion Fence**: sandy loam (0-5 cm) collected from the area east of the exclusion fence, west of the creek, and south of the walkway bridge to St. Marys school. Numerous very small black cinder-like and white ceramic-like pieces observed on the surface.	5	716680	4869750
Lions Park	Table 1	**North Play Area**: sandy loam (0-5 cm) collected from the northeast corner of the park, south of the swing set, west of the walkway bridge to St. Marys school, and east of the tennis court.	5	716643	4869746

Appendix 1 continued ...

Location	Table Reference	Detailed Description	Maximum Gamma μR/hr	GPS UTM	
				Easting	Northing
Lions Park	Table 1	**Northwest Field:** sandy loam (0-5 cm) collected from the play field in the northwest corner of the park.	5	716550	4869760
Lions Park	Table 1	**Sand Hill**: sand (0-5 cm) collected from the mid-slope of the sand hill on the west side of the park.	5	716540	4869700
Lions Park	Table 1	**Southwest Lawn**: sandy loam (0-5 cm) collected from the small grassy area in the extreme southwest corner of the park, adjacent to the west side of the south entrance.	5	716590	4869650
Lions Park	Table 2	**Trench 1**: centre field between the two baseball diamonds. 0-5 cm, fine sandy loam 10 cm, fine sandy loam 30 cm, fine sandy loam 60 cm, fine sandy loam 100 cm, fine sandy loam	 6 7 7 7 7	716670	4869746
Lions Park	Table 3	**Trench 2:** centre of north play area, west of walkway bridge. 0-5 cm, fine sandy loam 30 cm, fine sandy loam 70 cm, coarse aggregate foundry waste, pieces of brick and ceramic 90 cm, coarse aggregate foundry waste, pieces of brick and ceramic	 5 15 15 15	716643	4869746
Lions Park	Table 4	**Trench 3**: east end of north play area, south of walkway bridge 30 cm, fine sandy loam 50 cm, coarse aggregate foundry waste, pieces of brick and ceramic 60 cm, red-brown iron oxide-like sandy loam, above foundry waste 80 cm, red-brown iron oxide-like sandy loam, below foundry waste	 11 11 11 11	716660	4869760
St. Marys School	Table 5	**Adjacent to back stairway**: sandy loam (0-5 cm) collected from exposed soil next to the concrete stairs at the back of the school.	8	716780	4869800

Appendix 1 continued ...

Location	Table Reference	Detailed Description	Maximum Gamma μR/hr	GPS UTM	
				Easting	Northing
St. Marys School	Table 5	**Adjacent to concrete retainer**: sandy loam (0-5 cm) soil eroded from the slope to the north of the paved play area/portables, collected just behind the small concrete retainer. Scattered brick and ceramic-like chips observed on the surface.	6	716750	4869800
St. Marys School	Table 5	**Adjacent to concrete retainer**: sandy loam (0-5 cm) soil eroded from the slope to the north of the paved play area/portables, collected just behind the small concrete retainer. Scattered brick and ceramic-like chips observed on the surface.	6	716750	4869800
St. Marys School	Table 5	**Maple and elm grove**: dark sandy loam (0-5 cm) collected below elm and maple trees north of paved play area. Few very small brick and coal-like fragments observed on the surface.	8	716720	4869800
St. Marys School	Table 5	**Gravelly sand from play set**: coarse gravelly sand (0-5 cm) kicked out of play set adjacent to the west side of the play ground equipment.	6	716700	4869780
St. Marys School	Table 5	**Adjacent to Creek Edge**: sandy loam (0-5 cm) collected from grassy area between the west side of the play ground set and the creek edge.	6	716695	4869780
Caroline St. Park	Table 6	**East side, north of play equipment**: clay loam (0-5 cm), grassy area to the north side of the play ground equipment on the east side of the park.	7	717050	4870650
Caroline St. Park	Table 6	**West side, north of parking lot**: clay loam (0-5 cm), grassy area to the north of the parking lot.	7	717050	4870650

Gamma measurements made by Low Level Radioactive Waste Management Office.
GPS UTM - Global Positioning Satellite Universal Transverse Mercator position, zone 17.
The sample site titles in bold are the same sample site descriptors used in the data tables and the figures.

Appendix 2
Derivation and Significance of the MOEE "Ontario Typical Range" Soil Guidelines.

The MOEE "Ontario Typical Range" (OTR) guidelines are being developed to assist in interpreting analytical data and evaluating source-related impacts on the terrestrial environment. The OTRs are used to determine if the level of a chemical parameter in soil, plants, moss bags, or snow is significantly greater than the normal background range. An exceedence of the OTR_{98} (*the OTR_{98} is the actual guideline numbe*r) may indicate the presence of a potential point source of contamination.

The OTR_{98} represents the expected range of concentrations of chemical parameters in surface soil, plants, moss bags, and snow from areas in Ontario not subjected to the influence of known point sources of pollution. The OTR_{98} represents 97.5 percent of the data in the OTR distribution. This is equivalent to the mean plus two standard deviations, which is similar to the previous MOEE "Upper Limit of Normal" (ULN) guidelines. In other words, 98 out of every 100 background samples should be lower than the OTR_{98}.

The OTR_{98} may vary between land use categories even in the absence of a point source of pollution because of natural variation and the amount and type of human activity, both past and present. Therefore, OTRs are being developed for several land use categories. The three main land use categories are Rural, New Urban, and Old Urban. Urban is defined as an area that has municipal water and sewage services. Old Urban is any area that has been developed as an urban area for more than 40 years. Rural is all other areas. These major land use categories are further broken into three subcategories; Parkland (which includes greenbelts and woodlands), Residential, and Industrial (which includes heavy industry, commercial properties such as malls, and transportation rights-of-way). Rural also includes an Agricultural category.

The OTR guidelines apply only to samples collected using standard MOEE sampling, sample preparation, and analytical protocols. Because the background data were collected in Ontario, the OTRs represent Ontario environmental conditions.

The OTRs are not the only means by which results are interpreted. Data interpretation should involve reviewing results from control samples, examining all the survey data for evidence of a pattern of contamination relative to the suspected source, and where available, comparison with effects-based guidelines. The OTRs are particularly useful where there is uncertainty regarding local background concentrations and/or insufficient samples were collected to determine a contamination gradient. OTRs are also used to determine where in the anticipated range a result falls. This can identify a potential concern even when a result falls within the guideline. For example, if all of the results from a survey are close to the OTR_{98} this could indicate that the local environment has been contaminated above the *anticipated average,* and therefore the pollution source should be more closely monitored.

The OTRs identify a range of chemical parameters resulting from natural variation and normal human activity. ***As a result, it must be stressed that values falling within a specific OTR_{98} should not be considered as acceptable or desirable levels; nor does the OTR_{98} imply toxicity to plants, animals or humans.*** Rather, the OTR_{98} is a level which, if exceeded, prompts further investigation on a case by case basis to determine the significance, if any, of the above normal concentration. Incidental, isolated or spurious exceedences of an OTR_{98} do not necessarily indicate a need for regulatory or abatement activity. However, repeated and/or extensive exceedences of an OTR_{98} that appears to be related to a potential pollution source does indicate the need for a thorough evaluation of the regulatory or abatement program.

The OTR_{98} supersedes the Phytotoxicology ULN guideline. The OTR program is on-going. The number of OTRs will be continuously updated as sampling is completed for the various land use categories and sample types. For more information on these guidelines please refer to *Ontario Typical Range of Chemical Parameters in Soil, Vegetation, Moss Bags, and Snow. MOEE Report Number HCB-151-3512-93, PIBs Number 2792, ISBN 0-778-1979-1.*

Appendix 3
Derivation and Significance of the MOEE Soil Remediation Criteria (Clean-up Guidelines)

The MOEE Soil Remediation Criteria have been developed to provide guidance in cleaning up contaminated soil. They are not action levels, in that an exceedence of one or more of the criteria does not automatically mean that a clean-up must be conducted. A site clean-up may be conducted when a contaminated property is sold and/or the land use is changed. For example, the owner of an industrial property who plans to sell his/her land to a developer who intends to build residential homes can use the Remediation Criteria to clean up the soil to meet the residential land use criteria. This will allow the site to be reused for residential land-use without concern for adverse effects.

When contamination is found at a site where a change in land-use is not planned, the criteria may be used to assist in making decisions about adverse effects and the need for remediation. This is different from the previously described situation where a decision to change the land-use has already been made and the level of remediation required to rule out the potential for adverse effects is established by the new land use. Decisions on the need to undertake remedial action when the criteria are exceeded, and where the land use is not changing, require consideration of factors such as:

- the demonstrated presence or likelihood of an adverse effect (on and off property);
- an understanding of the type of protection provided by the criteria gained through knowledge of the exposure pathways and receptors which were considered in the development of the criteria, and through understanding how that combination of pathways and receptors relate to those which could be found at the site;
- an understanding of the relationship between dose and health response for sensitive receptors from all exposure pathways, including the safety and uncertainty factors that have been used in the development of the criteria;
- an understanding of the environmental characteristics of the contaminants and of the site conditions that could influence the migration of the contaminants and how this effects their exposure and response characteristics.

In each case, the decision to undertake or not undertake site remediation should entail all of these factors plus any additional factors specific to the site in question. When the decision is made that remedial action is needed, the criteria can be used as clean-up targets. If these criteria are unacceptable to the proponent undertaking the remediation, they have an option to develop local back-ground-based criteria or conduct a site specific risk assessment.

The Soil Remediation Criteria are effects-based concentrations set to protect against the potential for adverse effects to human health, ecological health, and the natural environment, whichever is the most sensitive. By protecting the most sensitive parameter the rest of the environment is protected by default. There are different Soil Remediation Criteria for soil texture, soil depth, and ground water use. The criteria have also been established so that there will not be a potential for adverse effects through contaminant transfer from soil to indoor air, from ground water or surface water through release of volatile gases, from leaching of contaminants in soil to ground water, or from ground water discharge to surface water. However, use of these criteria may not ensure that corrosive, explosive, or unstable soil conditions will be eliminated.

The Soil Remediation Criteria were developed from published U.S. EPA and Ontario environmental data bases. Currently there are criteria for about 25 inorganic elements and about 90 organic compounds. Criteria were developed only if there were sufficient, defendable, effects-based data on the potential to cause an adverse effect. All of the criteria address human health and aquatic toxicity, but terrestrial ecological toxicity information was not available for all elements or compounds. The development of Soil Remediation Criteria is a continuous program, and criteria for more elements and compounds will be developed as additional environmental data become available. Similarly, new information could result in future modifications to the existing criteria.

For more information on the Remediation Criteria please refer to the *Guideline for Use at Contaminated Sites in Ontario. Revised February 1997*, Ontario Ministry of Environment and Energy, PIBs 3161E01, ISBN 0-7778-5905-X.

Appendix 3

Soil Lead Information Sheet (inclosed)

Ministry of Environment and Energy

FOR YOUR information

NOVEMBER 1995

Frequently asked questions about lead in soil

WHAT IS LEAD?

Lead is a toxic heavy metal that is released into the environment through industrial sources, the previous use of leaded gasoline (now banned), disposal of lead wastes and the peeling or flaking of lead-based paint. Ontario residents are exposed every day to varying amounts of lead. Only about one per cent of our daily exposure to lead is from natural sources.

HOW MUCH LEAD IS THERE IN OUR SOIL?

Lead in surface soil in residential communities is often higher than 200 parts per million (ppm). In older, larger urban residential areas like Toronto, lead in soil may exceed 500 ppm, even when there is no local industrial source. Lead in soil in smaller communities is usually below 100 ppm.

IS LEAD HARMFUL?

Young children (aged six months to four years) are most at risk from lead exposure. Children take in an average of 80 milligrams of soils and dust (a volume of soil about the size of a grain of rice) each day while they play and, depending on the concentration of lead in soil, may develop high levels of lead in their blood.

In addition to direct exposure to soil, lead-contaminated soil contributes to the levels of lead found in dust within the home. Lead-based paints and industrial pollution can also contribute to lead dust in the home. Soil and dust are considered to be the major routes of exposure to lead for children.

The Ministry of Environment and Energy advises that there is minimal risk from exposure to soil with lead levels below 200 ppm.

HOW ARE CHILDREN AFFECTED?

High levels of lead in children may result in reduced hearing, muscle co-ordination and intellectual development. Lead contamination may also contribute either to lethargy or to aggressive behaviour.

If you have concerns and would like more information, contact your local office of the Department of Public Health or your medical doctor.

CAN I EAT VEGETABLES FROM MY GARDEN?

Lead enters and is stored in vegetables grown in lead-contaminated garden soils. The amount of lead taken up and stored in these vegetables will vary depending on the type of vegetable, the type of soil, your gardening practices and the amount of lead in the soil.

Although lead normally increases in plants as they age, lead is taken up and stored differently in roots and in plant leaves. For example, lettuce leaves can store seven times more lead than the roots of carrots. Beet leaves contain more lead than beet roots. Therefore, it is not always safe to assume that root vegetables will contain more lead than leafy vegetables. Fruit crops such as tomatoes, berries, apples an cucumbers, present a much lower risk because they take up and store very little lead.

For most people, there is minimal risk in consuming home-grown vegetables at soil lead levels below 200 ppm. However, this is only a guide and it should be remembered that eating vegetables grown in soil contaminated with lead will always increase your exposure to lead and the risk to your health, especially for young children.

WHAT CAN I DO TO REDUCE EXPOSURE TO LEAD?

- Keep your children away from soil contaminated with lead. Contaminated soil can be removed, or exposure can be reduced by covering the soil with clean soil or sod. Soil can also be paved over or covered with paving stones or decking.
- Wash children's hands and faces after playing outdoors and before eating.
- Clean your home regularly using a damp mop or damp cloth. Vacuuming and sweeping can increase dust levels in the home. Use a phosphate cleaner at least once a week, especially near window sills and doors. Use rugs, curtains and slipcovers that can be cleaned easily.
- Have forced air ducts cleaned by professionals and replace furnace filters often.
- Avoid bringing outdoor dirt inside by removing outdoor shoes.
- Brush pets often as their fur collects dust. Pet should be brushed outside if possible.
- Keep children's toys and play areas clean; discourage mouthing activities such as eating dirt.
- Don't let your children eat paint chips. They like them because the lead in the paint makes the chip taste sweet.
- Locate your vegetable garden at least one metre (three to four feet) away from roads, driveways and down spouts. Also make sure your garden is at least a metre away from sources of flaking paint such as walls, sheds and fences.
- Before eating, wash all vegetables thoroughly and peel skin from root crops.
- If your soil is contaminated with lead, don't feed garden vegetables to young children or use them in baby food recipes.

HOW CAN I GET MORE INFORMATION?

If you live in the vicinity of a source of lead pollution and you suspect your soil may be contaminated, contact your local office of the Ministry of Environment and Energy.

Contact your local office of the Department of Public Health or your medical doctor if you are concerned about being exposed to lead or have questions about health effects.